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Original Research

The most effective type of feedback for rehabilitation in different types of impairment of upper limb function in patients with chronic stroke

Level of impairment and type of feedback

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Abstract

Aim: The ultimate goal for many stroke patients is to achieve maximum level of functional independence that enables them to return home and reintegrate into community life as fully as possible. There are variable levels of impairment in stroke patients. Detecting the suitable type of feedback (visual or auditory) is important for improvement the impairment of stroke patients. Material and Method: Sixty left chronic stroke patients were representinging the samples of the study. The patients were assigned into four equal groups; The patients in group1(G1) and group 2 (G2) were of mild impairment of upper limb function while patients in group3 (G3) and group4 (G4) were of moderate impairment of upper limb function. Each group was tested by WMFT for detecting the function and time of motor performance of upper extremity(UE) . G1 and G3 received visual feedback training while G2 and G4 received auditory feedback training. Results: There was a significant increase in the degree of motor performance in all of the four groups G1, G2, G3 and G4 P value was less than with more evidence for .05 with more evidence for G1. Also there was a significant decrease in the time of motor performance in all the four groups P value was less than .05 with more evidence for G3. Discussion: Visual and auditory feedback have an effect on improving the motor performance of UE in mild and moderate impairment stoke patients with more evidence for visual feedback.

Keywords

Impairment; Stroke; Visual Feedback; Auditory Feedback

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Introduction

Stroke survivors have approximately two thirds of residual neurological deficits that impair function. Dysfunction from upper extremity (UE) hemiparesis specifically, impairs performance of many daily activities and reduces functional independence [1]. Neural plasticity or Neuroplasticity (also variously referred to as brain plasticity, cortical plasticity or cortical re-mapping) refers to the changes that occur in the organization of the brain and nervous system as a result of experience. The concept of neuroplasticity focus on, the brain areas are still re-wiring in response to changes in the environment [2].

The substantial changes usually occur in the lowest neocortical processing areas. These changes can profoundly alter the pattern of neuronal activation in response to experience. According to the theory of neuroplasticity, thinking, learning, and acting actually change both the brain›s physical structure, or anatomy, and functional organization, or physiology from top to bottom. Today neuroscientists believe that the brain is not immutable after the development but it continues to change and develop neuroplasticity. This means that both structural and functional aspects of the brain are flexible depending on the type of learning or rehabilitation [3-4].

Feedback of performance plays a central role in skill acquisition or learning ability. After a stroke, intrinsic feedback mechanisms are often impaired. Extrinsic (or augmented) feedback is of great importance for motor relearning and neuroplasticity. Physiotherapists currently provide feedback in various forms, including verbal comments and demonstration. In clinical practice, mirrors or video-recordings are used to provide the patients with visual feedback of their movement performance. These methods teach the patients the correct and the compensatory strategies of movement. The brain has a remarkable ability to reorganize its neural connections in response to sensory stimulation or sensory feedback especially after brain injury. The efficiency and speed of the motor recovery process depend on the availability of sensory information provided by motor activity and the feedback. There are different types and degree of impairment in stroke patients that response widely to feedback methods [5-6].

For this purpose we choose to study the response of two different degrees of impairment of UE to visual and auditory feedback training.

Material and Method

This study was conducted to assess the effects of the visual and auditory feedback training on the arm performance (physical effect) in patients suffering from stroke for more than one year with mild and moderate impairment of upper limb function (comparative study). The best type of feedback training for each type of impairment of upper limb (UL) was determined by its impact on improving the motor performance of the affected upper limb. The improvement of the motor performance was based on increasing the functional ability of the upper limb and decreasing the time of its performance.

Selection of the subjects

Sixty left chronic stroke patients were representing the samples of the study. The patients were assigned into four equal groups. All the patients referred from a neurologist. The diagnosis was confirmed by MRI &/or CT scan. The patients were selected from the Out-Patient Clinic, Faculty of Physical Therapy, and Cairo University. All the patients were matched for age and duration of the stroke. The affected upper limb had mild and moderate motor impairment according to Fugle–Myer scale for the section of upper limb [7].After receiving an extensive explanation about the protocol, all the patients were given an informed consent to participate in this the study (written). A prospective, randomized, single-blind, pre-post-test.

Group I (G1)

The patients in group I (G1) were treated by forward arm reaching. All the patients in this group were mild impairment of function in the affected UL. The exercise was done in from a sitting position by using the mirror as a visual feedback.

Group II (G2)

The patients in group II(G2) were treated also by forward arm reaching. All the patients in this group were also mild impairment of function in the affected UL. The exercise was done in from a sitting position by using verbal instructions as an auditory feedback.

Group III (G3)

The patients in group III (G3) were treated by forward arm reaching. All the patients in this group were moderate impairment of function in the affected UL. The exercise was done in from a sitting position by using the mirror as a visual feedback.

Group IV (G4)

The patients in group IV (G4) were treated also by forward arm reaching. All the patients in this group were also moderate impairment of function in the affected UL. The exercise was done in from a sitting position by using verbal instructions as an auditory feedback.

Assessment of the subjects

All the patients were subjected to a complete neurological examination of detailed medical history, motor, sensory and ADL examination. Fugle-Meyer assessment scale (FMAS) of the upper extremity motor performance section was used to determine the severity of motor impairment of the upper limb and to divide patients into mild and moderate impairment. Wolf Motor Function Test (WMFT) was used also to time the movement of the upper limb and also to measure the functional performance of the upper limb as a whole. WMFT was done two times for each patient; before beginning the treatment (pre- test) and immediately after the end of treatment (post- test) .

A- Fugle-Meyer assessment scale (FMAS)

The upper extremity section test of (FMAS) was used to assess the degree of impairment of the upper limb motor function. It is a valid and reliable test. It correlates well with inter joint UE coordination of stroke patients. It has a top score of 66 for UL section [8]. It was used for selecting the patients and dividing them into mild and moderate impairment. An intraclass correlation coefficient (ICC) of 0.990 was for FMAS [8].

B- Wolf Motor Function Test (WMFT)
It is a reliable test to measure functional ability in a variety of activities and is more sensitive than other upper extremity (UE) tools. The timed items of (WMFT) assess the speed of performance so the changes in the temporal and spatial parameters of the upper limb will be detected by this test. The motor performance and time of performance sections of (WMFT) were used to quantify the UE motor ability through functional tasks and time. Each patient was asked to apply each item of (WMFT) as quickly as possible and truncated at 120 seconds. An intraclass correlation coefficient (ICC) of 0.995 was for WMFT [8].

Procedure
• Mild impairment patients of the functions of the upper limb were divided into G1 and G2. Patients in G1 were trained by forward reaching to 90 degrees in front of the mirror from sitting position while patients in G2 were treated as G1 but with verbal instructions to reach to 90 degrees of forward flexion.
• Moderate impairment patients of the functions of the upper limb were divided into G3 and G4. Patients in G3 were trained by forward reaching to 90 degrees in front of the mirror from sitting position while patients in G4 were treated as G3 but with verbal instructions to reach to 90 degrees of forward flexion.
• The researcher helped the patients as needed to attain the desired position of reaching. The exercises were repeated for one hour for each patient with the period of rest after each movement equal to the time of action for each repetition to perform the forward reach.
• The designed physical therapy training was given to each group. After accomplishing the designed physical therapy training of each group, all groups were tested again by WMFT after one and half a month of training for three sessions per week.

Statistical analysis [9]
• The mean of the time and degree of motor impairment by WMFT were taken.
• Wilcoxon test was used to determine the significant changes after training for each group.
• Mann –Whitney U test was used to compare between both groups of the same level of impairment.
• SPSS for Windows Version 17 was used for all statistical analyses. All statistical procedures were two-tailed with significance set at α level= 0.05

Results
1- Wolf Motor function test (WMFT) for functional performance
The median values of motor performance of pre-test at G1 and G2 were 33.29±9.1 and 31.86 ± 8.3 respectively. The mean values of motor performance of pre-test at G3 and G4 were 20.86 ± 8.3 and 21.7±9.1 respectively. Comparison of the mean values of motor performance at G1 and G2 and also G3 and G4 showed no significant difference of motor performance between the two groups (P≤.574) and (P≤.570).
The median values of motor performance of G1 at pre and post-tests were 33.29 ± 9.1and 60.86 ± 12.8 respectively. Comparison of the mean values of motor performance of G1 at pre and post- tests showed a significant increase of motor performance over the two periods of assessment (P≤.002) (Figure 1).

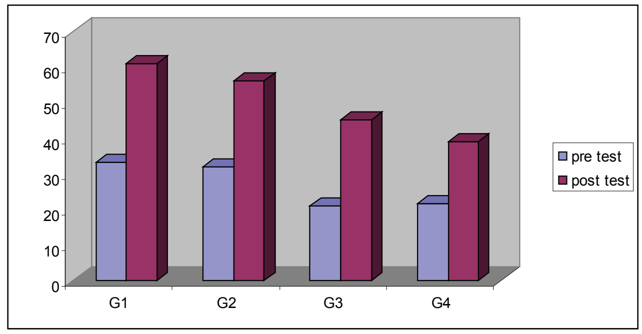

Figure 1. The mean values of WMFT (functional performance) for each group.

The median values of motor performance of G2 at pre and post tests were 31.86 ± 8.3 and 56.14 ± 12.8 respectively. Comparison of the mean values of motor performance of G2 at pre and post tests showed a significant increase of motor performance over the two periods of assessment (P≤.004) (Figure 1).
The median values of motor performance of G3 at pre and post-tests were 20.86 ± 8.3 and 45.14 ± 12.8 respectively. Comparison of the mean values of motor performance of G3 at pre and post tests showed a significant increase of motor performance over the two periods of assessment (P≤.008) (Figure 1).
The median values of motor performance of G4 at pre and post tests were 21.7 ± 9.1 and 39.1 ± 8.3 respectively. Comparison of the mean values of motor performance of G4 at pre and post- tests showed significant increase of motor performance over the two periods of assessment (P≤.018) (Figure 1).
The median values comparison of the motor performance of post- test at G1 and G2 showed a significant increase of motor performance in G1 (P≤.005) and Comparing the mean values of G3 and G4 showed a significant increased in G3 (P≤.015).

2-Wolf Motor function test for the time of motor performance
The mean values of pre test of the time of motor performance at G1, G2, G3 and G4 were 1443 ± 41, 1440 ± 43, 1552 ± 43 and 1550 ± 41 respectively. Comparison of the mean values of time of motor performance at G1 and G2 and also G3 and G4 showed no significant difference for the time of motor performance between the two groups comparison (P≤.917) and (P≤.910) respectively (Figure 2).
The mean values of the time of motor performance of G1 at pre and post-tests were 1443 ± 41 and 750 ± 43 respectively. Comparison of the mean values of the time of motor performance of G1 at pre and post -tests showed a significant changing for the time of motor performance over the two periods of assessment (P≤.000) (Figure 2).
The mean values of the time of motor performance of G2 at pre and post- tests were 1440 ± 43 and 771 ± 47 respectively. Comparison of the mean values of the time of motor performance of G2 at pre and post- tests showed a significant changing for the time of motor performance over the two period of assessment (P≤.000) (Figure 2).
The mean values of the time of motor performance of G3 at pre and post -tests were 1552 ± 43 and 900 ± 43 respectively. Comparison of the mean values of the time of motor performance of G3 at pre and post- tests showed a significant changing for the time of motor performance over the two periods of assessment (P≤.000) (Figure 2).

The mean values of the time of motor performance of G4 at pre and post-tests were 1550 ± 41 and 940 ± 43 respectively. Comparison of the mean values of the time of motor performance of G4 at pre and post- tests showed a significant changing for the time of motor performance over the two periods of assessment (P≤.000) (Figure 2).

The mean values of post test of the time of motor performance at G1 and G2 showed a significant decrease in the time of motor performance in G1 (P≤.000). Comparing the mean values of G3 and G4 showed a significant decrease in the time of motor performance in G3 (P≤.000).

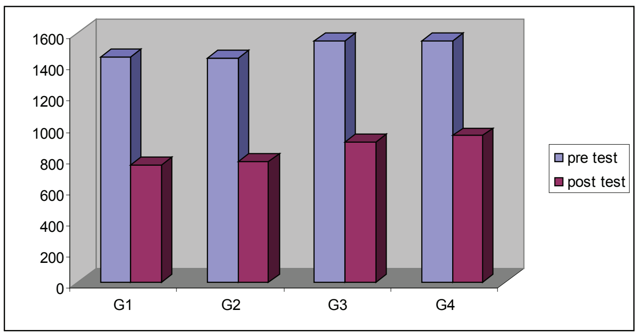

Figure 2. The mean values of WMFT (time of performance) for each group.

Discussion

Sensory Integration is the ability to receive, organize and interpret sensory input from multiple systems in order to act on or within the environment. Visual feedback or auditory increases sensory integration and learning abilities so enhance neural plasticity in stroke patients. **Walker et al and Van et al.** concluded that parieto-occipital cortex is crucial for the processing of the visually perceived limb configuration and thus mediating the effects of arm training. This might explain although both types feedback improve arm performance but visual feedback decreases the time of arm movement by WMFT than auditory feedback in the current study [10-11]. This is agreed also by **Dohle et al. and Grefkes et al.** [12-13]**.**

The primary sensory and motor cortices are organized symmetrically in the left and right hemispheres. Unilateral cortical stroke produces severe damage. It causes changes in the transcallosal inhibition resulting in hyperexcitability of the unaffected motor cortex. Increasing the excitability of the intact hemisphere represents a compensatory mechanism for the motor recovery. A consequence of the over- activation of an intact hemisphere, the lesioned hemisphere receives abnormally strong interhemispheric inhibition from the intact one. This inhibition rises with increasing level of impairment and chronicity. And as mentioned above that parieto-occipital cortex is crucial for the processing of the visually perceived limb configuration, thus mediating the effects of the arm. This might explain why in moderate impairment visual feedback had significant effect on improvement function by WMFT than auditory feedback because visual feedback decrease this inhibition than auditory feedback so more effective in moderate impairment stroke patients. This is agreed by **Floel et al.** [14]

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest

None of the authors received any type of financial support that could be considered potential conflict of interest regarding the manuscript or its submission.

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